Watershed Characterization Document
Scott Creek: (Hydrologic Unit Code: 03050109-150-060); Station S-044
Fecal Coliform Bacteria

DHEC

PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control

Bureau of Water
2600 Bull Street
Columbia, SC 29201

April 20, 2004

Abstract

A TMDL was developed for Scott Creek, a small, mostly urban stream in Newberry County, SC. This stream was placed on South Carolina's 303(d) list of waters that are impaired, because 42 % of water samples in the 1998 - 2002 assessment period exceeded the standard for fecal coliform. The principal land uses in the Scott Creek watershed were 53 % urban, 27 % forest, and 19 % agricultural in 1992. Scott Creek has shown improvement in water quality since 1998.

The load-duration curve methodology was used to calculate the existing load and the TMDL load for Scott Creek at S-044. The existing load was estimated to be 2.18E+11 cfu/day. The Load Allocation was determined to be 3.96E+10 cfu/day, which equates to a reduction in the load of fecal coliform into the creek of 82 %. This watershed has no MS4s. Resources and several TMDL implementation strategies to bring about this reduction are suggested.

Table of Contents

Tables

Figures

1.0 INTRODUCTION

1.1 Background

Levels of fecal coliform bacteria can be elevated in water bodies as the result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in stream water quality conditions so that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA 1991).

1.2 Watershed Description

Scott Creek drains a small, mostly urban watershed in Newberry County. The creek flows through the middle of the town of Newberry (Figure 1). Scott Creek is a tributary of the Bush River, joining the river in an arm of Lake Murray. The watershed is in the lower Piedmont region of South Carolina. The area of the watershed is small, 1187 hectares (2934 acres). Most of the city of Newberry is in the watershed. Approximately 6300 people lived in the watershed in 2000. Of these about 800 lived outside the town limits of Newberry.

The predominant land uses in the watershed, based on the National Land Cover Dataset (NLCD) (circa 1992), were urban (53 %), forest (27 %); and agricultural (19 %); see Table 1 and Figure 2. Agricultural activities are mainly in the upper and lower ends of the watershed.

Scott Creek has a single water quality monitoring station (S-044), which is located at SC-34 south of the city of Newberry. This TMDL applies to the watershed upstream of this point.

1.3 Water Quality Standard

The impaired stream segment, Scott Creek, is designated as Class Freshwater. Waters of this class are described as follows:

> "Freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses." (R.61-68)

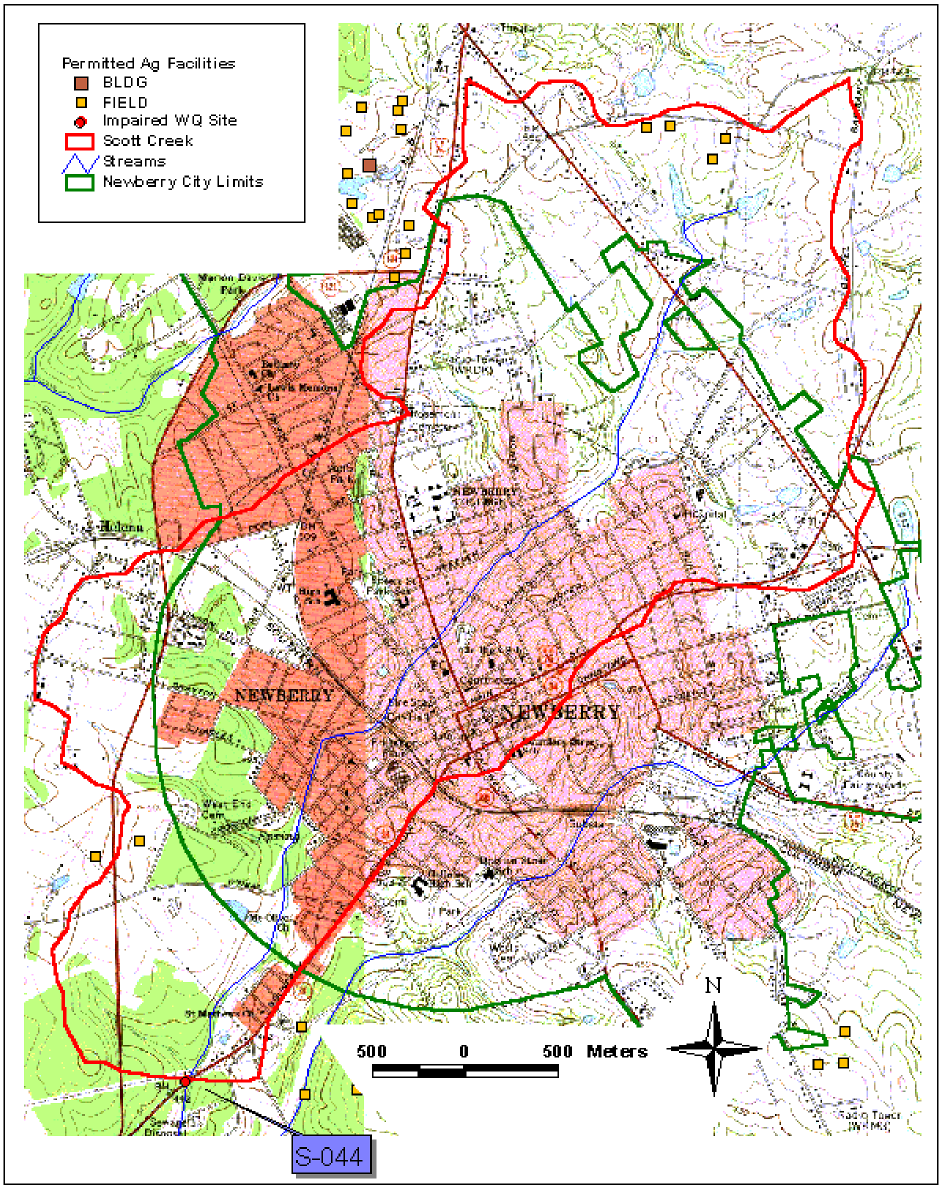

Figure 1. Map of the Scott Creek watershed.

South Carolina's standard for fecal coliform in Freshwater is:

> "Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml."(R.61-68).

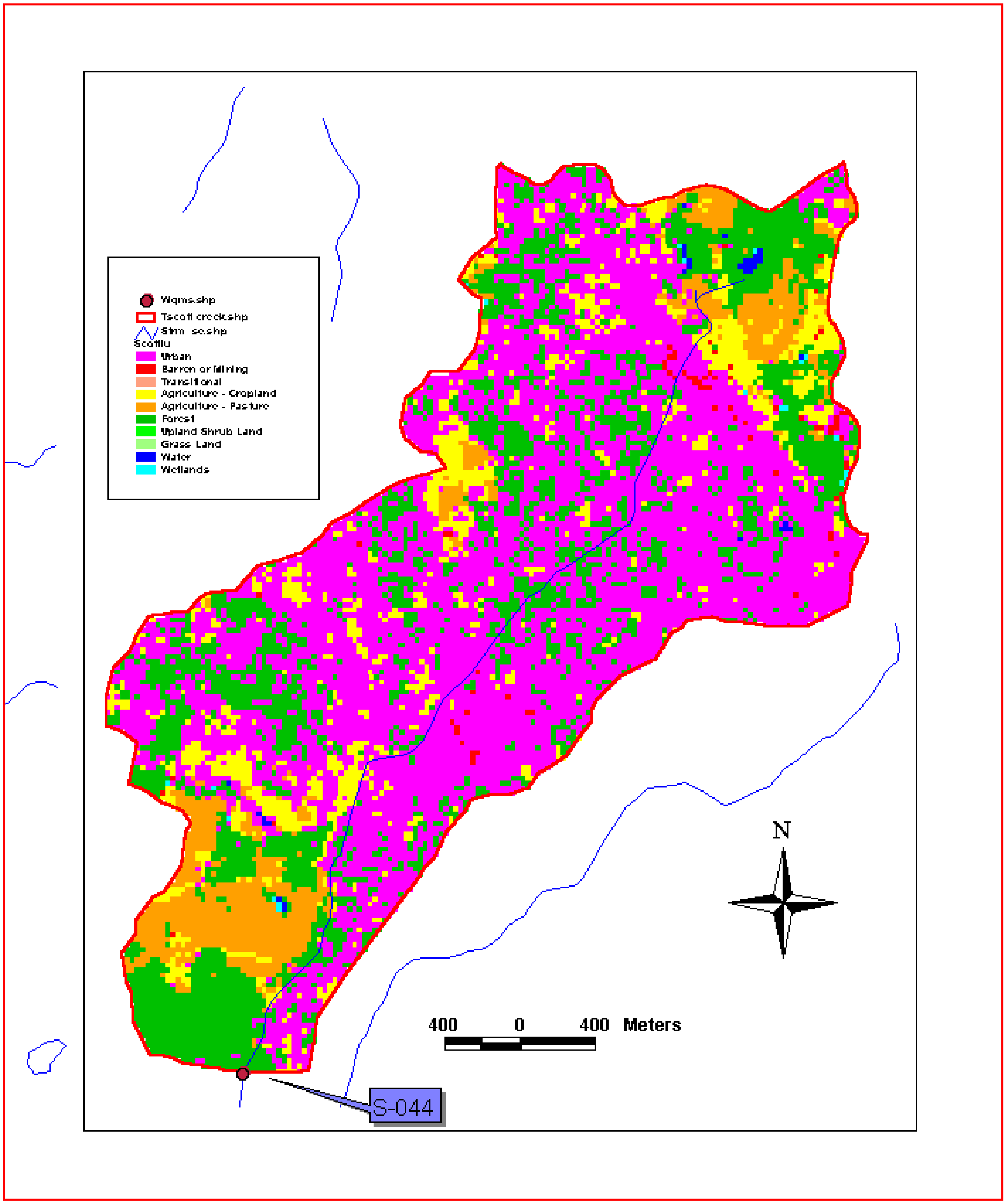

Figure 2. Map showing land uses in the Scott Creek watershed.

Table 1. Land uses in the Scott Creek watershed.

Land Use Groups	Land Use	Area (hectares)	Area Sub-totals (hectares)	% Land Use	Sub-totals %
	Water	3.2		0.3%	
Developed	Residential Low Density	307.2		25.9%	
	Residential High Density	95.4		8.0%	
	Commercial, Industrial, & Transportation	229.4		19.3%	
			632.0		**53.2%**
	Barren	7.2		0.6%	
Forest	Forest Deciduous	35.8		3.0%	
	Forest Evergreen	195.1		16.4%	
	Forest Mixed	84.3		7.1%	
			315.3		**26.6%**
Agricultural	Pasture/Hay	102.2		8.6%	
	Cropland	59.6		5.0%	
	Urban Grasses	65.7		5.5%	
			227.5		**19.2%**
	Wetlands Woody	1.8		0.2%	
Total for Watershed		**1186.9**		**99.8%**	**99.0%**

2.0 WATER QUALITY ASSESSMENT

The assessment of water quality data for the 2004 303(d) list (1998 through 2001 data) indicated that Scott Creek is impaired for recreational use. Samples were collected at water quality monitoring station S-044 (Scott Creek at SC-34). In addition to being on the 2004 303(d) list, Scott Creek was also on the 1998, 2000, and 2002 lists. Waters in which no more than 10% of the samples collected over a five year period are greater than 400 fecal coliform counts (or cfu) per 100 ml are considered to comply with the South Carolina water quality standard for fecal coliform bacteria. Waters with more than 10 percent of samples greater than 400 cfu/ 100 ml are considered impaired by fecal coliform bacteria and are placed on South Carolina's 303(d) list. During the assessment period (1998-2002), 41 % of the samples did not meet the fecal coliform criterion at S-044. Fecal coliform data for the period of 1990-2001 (Scott Creek was not sampled in 2002.) are provided in Appendix A.

Fecal coliform concentrations in Scott Creek appear to be decreasing (Figure 3). The percentage of standard exceedences for the biannual 303(d) lists has decreased from 87 % in 1998 to 42 % in 2004 (Table 2). The decrease in load could be partially attributed to the drought that occurred from 1998-2002. A more significant cause may be improvements to the collection system by Newberry

(Andy Miller, Saluda Basin Watershed Manager, 2004, personal communication). Implementation of this TMDL should be built on the improvements already seen in this watershed.

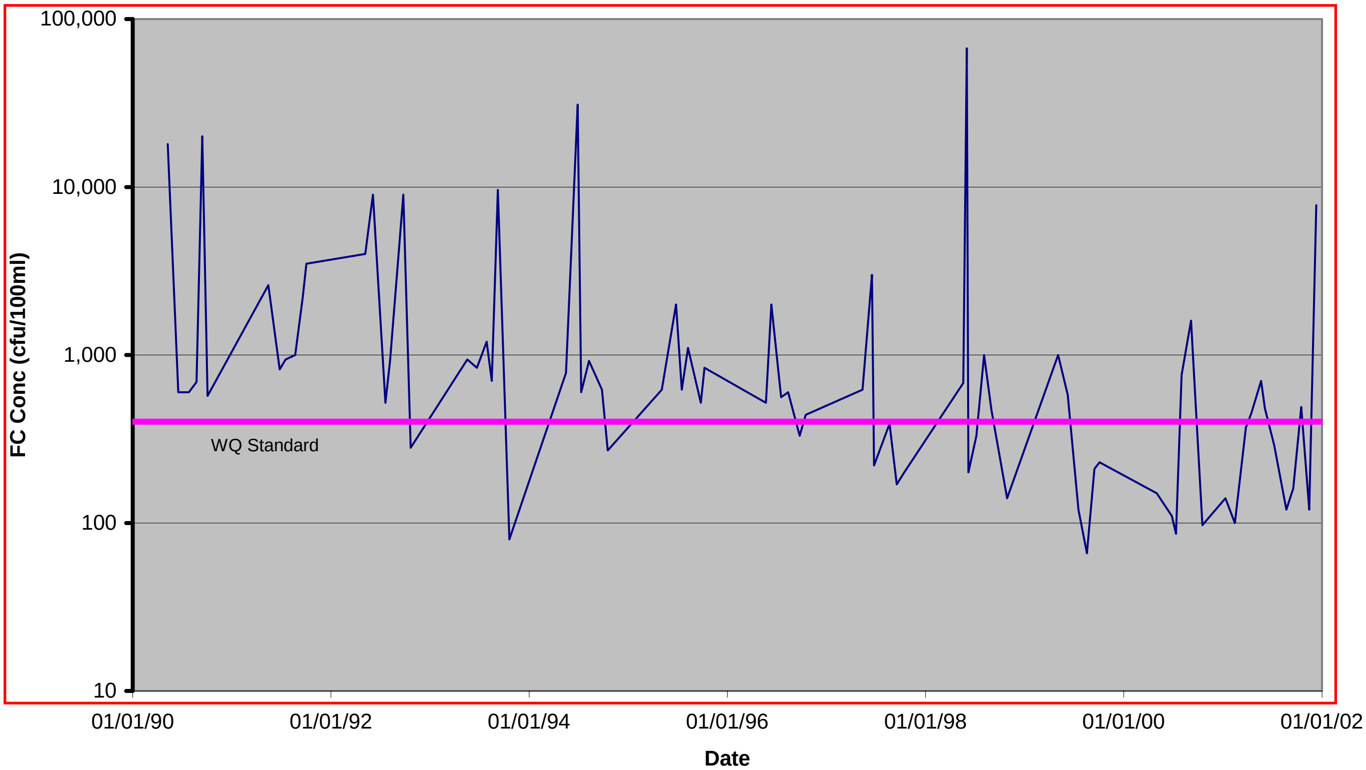

Figure 3. Fecal coliform concentrations in Scott Creek from 1990 through 2001.

While storm events do frequently cause increases in the fecal coliform concentration in Scott Creek, exceedences of the standard also occur during dry periods. This suggests that sources of fecal coliform include both runoff and continuous sources.

Table 2 Comparison of percentages of standard exceedences by 303(d) list.

303(d) List	**Assessment Years**		**Percent-age**
1998	1992-1996		87%
2000	1994-1998		69%
2002	1996-2000		47%
2004	1998-2002		42%

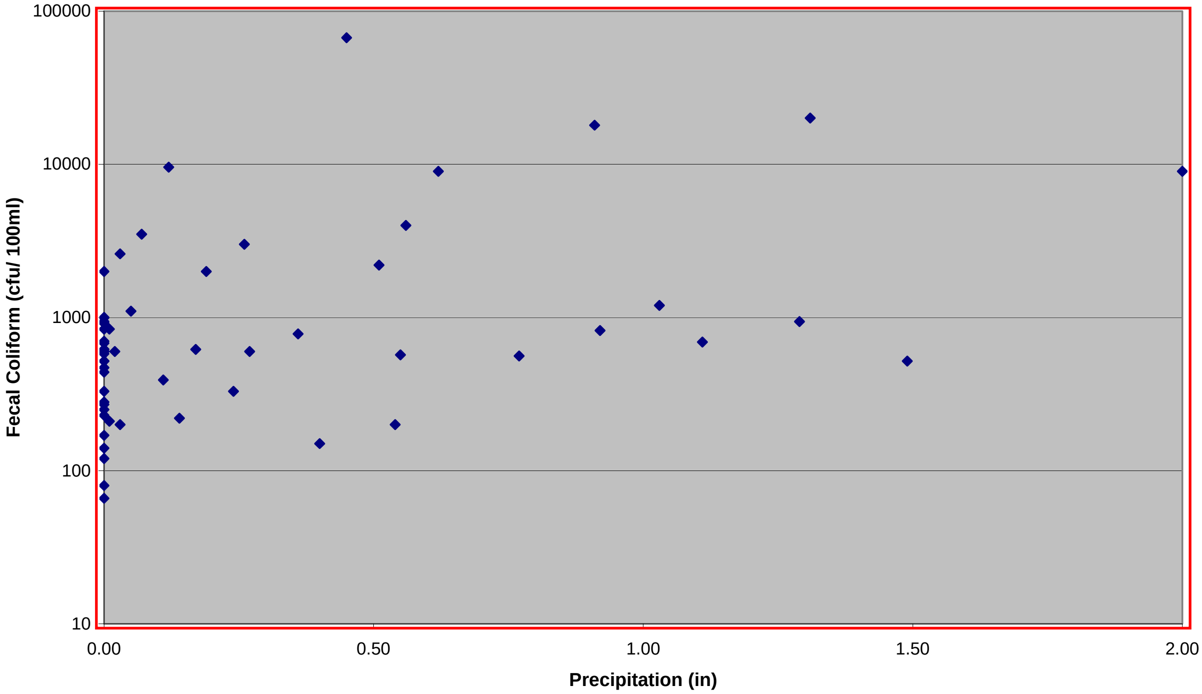

Figure 4 Relationship between precipitation and fecal coliform concentrations in Scott Creek.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria are used by the State of South Carolina as the indicator for pathogens in surface waters. Pathogens, which are usually difficult to detect, cause disease and make full body contact recreation in lakes and streams risky. Indicators such as fecal coliform bacteria, enteroccoci, or E. *Coli* are easier to measure, have similar sources as pathogens, and persist a similar or longer length of time in surface waters. These bacteria are not in themselves usually disease causing.

There are many sources of pathogen pollution in surface waters. In general these sources may be classified as point and nonpoint sources. With the implementation of technology-based controls, pollution from point sources, such as factories and wastewater treatment facilities, has been greatly reduced. These point sources are required by the Clean Water Act to obtain a NPDES permit. In South Carolina NPDES permits require that dischargers of sanitary wastewater meet the state standard for fecal coliform at the point of discharge. Municipal and private sanitary wastewater treatment facilities may occasionally be sources of pathogen or fecal coliform bacteria pollution. However, if these facilities are discharging wastewater that meets their permit limits, they are not causing the impairment. If one of these facilities is not meeting its permit limits, enforcement of the permit limit is required. A TMDL is not necessary for this purpose. Pathogen or fecal coliform TMDLs are therefore essentially nonpoint source TMDLs even though the TMDL may include a wasteload allocation for a point source.

3.1 Point Sources in the Scott Creek Watershed

There is no currently operating NPDES facility (point source) in this watershed.

Though there is no treatment facility or outfall in this watershed, there are many sewer lines (Figure 5). Sewage collection systems typically are placed adjacent to waterways. At these locations, there is a potential for collection system leaks which could result in elevated instream concentrations of fecal coliform bacteria. Sanitary sewer overflows (SSOs) are also a potential source, particularly after periods of intense rainfall. This source is associated with infrequent events, limited in duration and likely to have an insignificant long-term impact instream. Identified collection system and/or SSO problems are addressed by SCDHEC through compliance and enforcement mechanisms. Previously mentioned was improvements to the collection system by the town of Newberry that may be the cause of the reduction in fecal coliform load to Scott Creek since 1996.

3.2 Nonpoint Sources in Scott Creek Watershed

3.2.1 Wildlife

In this urban watershed wildlife (mammals and birds), which is a source of fecal coliform bacteria, is likely to be a significant though not major contributor. Many animals, such as squirrels, raccoons, and geese, have adapted to live in suburban environments. The population density of these animals seems often to be higher than in more natural environments.

3.2.2 Failing Septic Systems

The part of the watershed that is within the town limits of Newberry has sewer service. Areas outside of the town of Newberry may not. Because most of the watershed is served by sewage treatment, the number of septic systems is probably small. Therefore failing septic systems are unlikely to be a significant source of fecal coliform bacteria.

3.2.3 Agricultural Activities

Though this watershed is largely urban, the upper and lower ends of the watershed are rural. There are four fields in the upper part of the watershed and one field in the lower end, that are permitted by DHEC for application of animal waste, broiler and layer manure, respectively. Chicken litter (manure) that is not properly stored or applied to land is a potential source of fecal coliform bacteria. Application of excessive amounts of litter, that is adding more than the crop can use, and applying the litter too close to streams are possible methods by which litter can pollute streams.

3.2.4 Urban Runoff

Urbanized or developed land typically generates an increased loading for pollutants relative to forest and other undeveloped land uses. Dogs, cats, and other pets are the primary source of fecal coliform deposited on the urban landscape. There are also 'urban' wildlife, such as squirrels, raccoons, pigeons, and other birds, all of which contribute to the fecal coliform load. Impervious surfaces increase the amount of runoff relative to predevelopment. The increased storm runoff washes more of this fecal material into streams directly or through the storm sewers. The town of Newberry has not been designated as a Municipal Separate Storm Sewer System (MS4) area at this time.

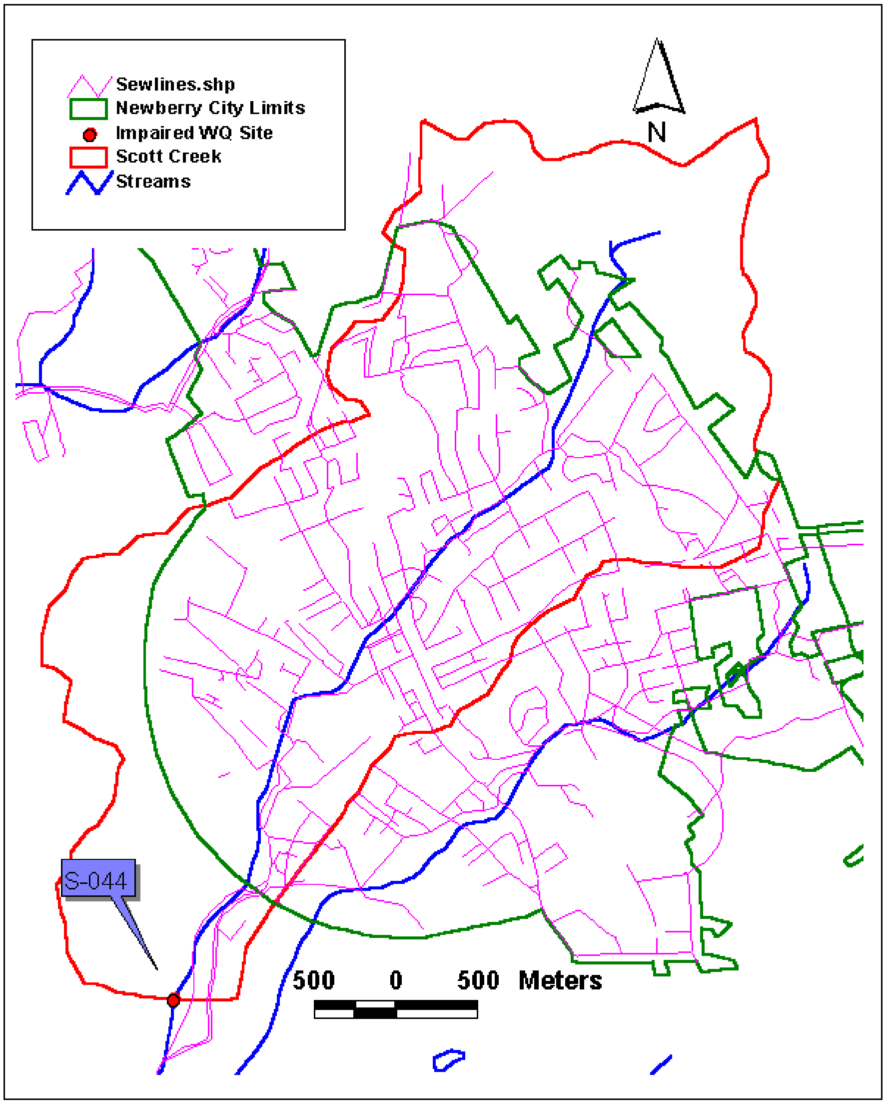

Figure 5 Location of sewer lines in Scott Creek watershed at Newberry.

4.0 LOAD-DURATION CURVE METHOD

Load-duration curves were developed as a method of developing TMDLs that applies to all hydrologic conditions. The load-duration curve method uses the cumulative frequency distribution of stream flow and pollutant concentration data to estimate the existing and the TMDL loads for a water body. Development of the load-duration curve is described in this chapter.

In the ideal situation a long period of record for flow data would be available for the water body of interest. A longer period of record increases the confidence in the results of the load-duration method. Scott Creek, like most small streams in South Carolina is not gauged. Smith Branch, an urban watershed in Columbia, SC, is a comparable, gauged stream with similar land uses and topography. Data from the gauge (USGS # 02162093) on Smith Branch for the period of record (October 1, 1976 to September 30, 2001) was used to estimate the flow in Scott Creek. The estimated flow was used to generate the flow-duration curve. The Smith Branch watershed is somewhat larger, 1444 hectares, compared to 1187 hectares for the Scott Creek watershed. The watersheds are some 40 miles apart so that rainfall would be similar at both watersheds.

The flows for Scott Creek were estimated by multiplying the daily flow rates from Smith Branch by the ratio of the Scott Creek drainage area to that of Smith Branch (0.8220). The flows were ranked in ascending order and the flow exceedences at certain selected percentiles determined (eg. 0.1, 0.15 0.2, …). The load-duration curve was generated by calculating the load from the observed fecal coliform concentrations, the flow rate that corresponds to the date of sampling, and a conversion factor. The load was plotted against the appropriate flow recurrence interval to generate the curve (Figure 6). The target line was created by calculating the allowable load from the flow (at 5 % recurrence intervals) and the instantaneous fecal coliform standard concentration. The points were connected to make the line. Sample loads above this line are violations of the standard, while loads below the line are in compliance.

The water quality target was set at 380 cfu/100ml for the instantaneous criterion, which is five percent lower than the water quality criteria of 400 cfu/100ml. A five percent explicit Margin of Safety (MOS) was reserved from the water quality criteria in developing the load-duration curves. The instantaneous criterion was targeted as a conservative approach and should be protective of both the instantaneous and 30-day geometric mean fecal coliform bacteria standards.

The best fitting trend line for loads that were above the target line (samples that exceeded the instantaneous water quality standard) was a power function. This trend line has an r^2 of 0.6683 and has a similar shape to the target line. The existing load to Scott Creek was calculated from the mean of all loads exceeding the standard that were between the 10 % and 90 % flow exceedence limits at 5 % intervals. Only extreme flows (at both the lower and upper frequencies) that occur infrequently, are excluded.

The TMDL load is calculated from the target line. Load values at 5 % occurrence intervals along the target line from 10 to 90 % were averaged. The Load Allocation (LA) values are derived from the 380 cfu/100ml water quality target, which includes the explicit Margin of Safety. Calculations for both existing and TMDL loads are provided in Appendix B.

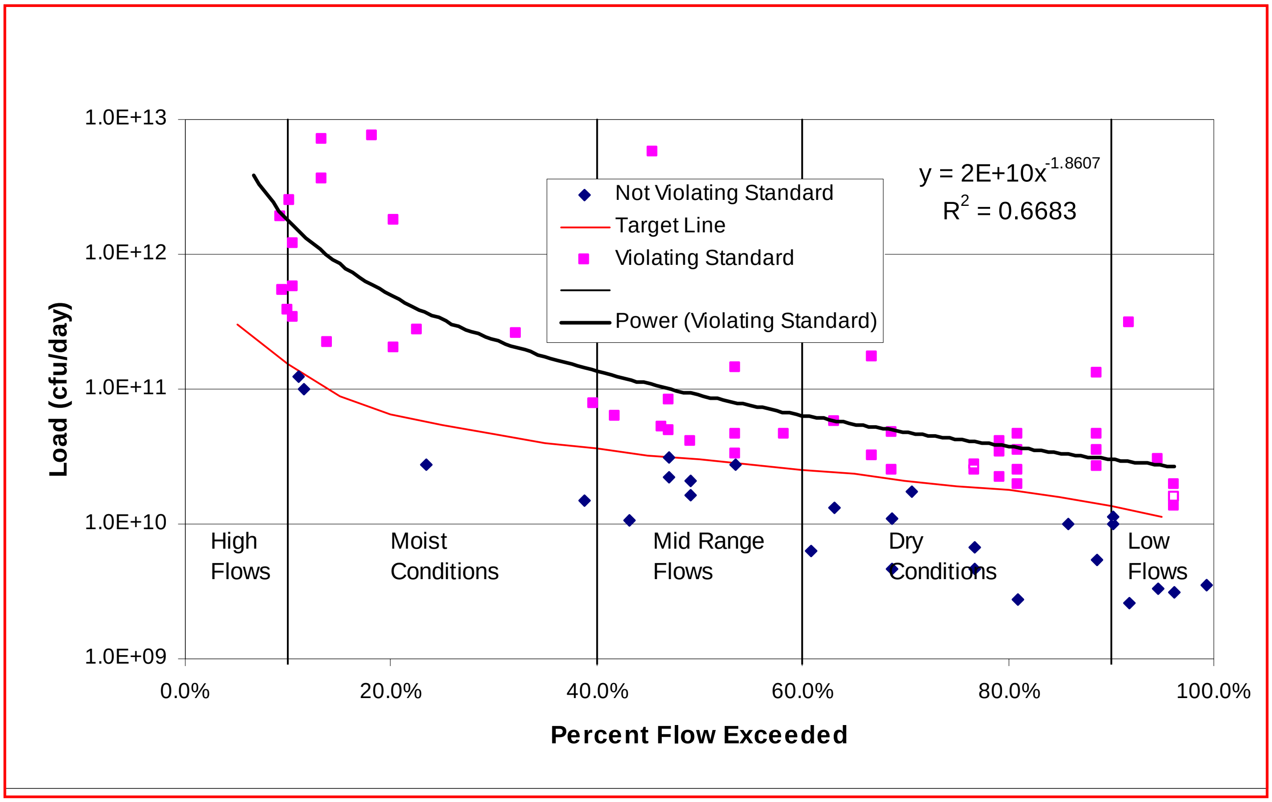

Figure 6. Load-duration curve for Scott Creek at S-044. Trend line for loads that are above the allowable limit is a power function.

5.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

A total maximum daily load (TMDL) for a given pollutant and water body is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

$$\textbf{TMDL} = \Sigma\ \textbf{WLAs} + \Sigma\ \textbf{LAs} + \textbf{MOS}$$

The TMDL is the total amount of pollutant that can be accepted or assimilated by the receiving water body while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis to establish water quality-based controls.

5.1 Critical Conditions

This TMDL is based on the flow recurrence interval between 10 % and 90 %. This encompasses 80 % of flows in Scott Creek. Only flows that are characterized as 'High' or 'Low' flows in Figure 6 are not included in the analysis. For this TMDL critical conditions are this range of the flow recurrence interval.

5.2 Seasonality

The data used to derive the TMDL includes data from all months of the year, though the data were biased toward the warm months of the season. The warm season is the time of the year when children are more likely to be playing in the creek or adults are likely to be engaging in recreation activities in the creek or the river downstream of the mouth of Scott Creek.

5.3 Margin of Safety

The explicit margin of safety is 5% of the geometric mean standard or 10 cfu/ 100ml of the instantaneous criterion of 400 cfu/100 ml. For S-044 this is equivalent to 2.1 E+09 cfu/day**.**

5.4 TMDL

For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of cfu or organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l). The resulting TMDL should be protective of both the instantaneous, per day, and geometric mean, per 30-day, criteria.

Table 3. TMDL components for Scott Creek.

Impaired Station	WLA cfu/day	LA cfu/day	MOS cfu/day	TMDL cfu/day	Percent Reduction
S-044	NA	3.96×10^{10}	2.1×10^{9}	4.1×10^{10}	82.1 %

The target loading value is the load to the creek that it can receive and meet the water quality standard. It is simply the TMDL minus the MOS. The target loading for Scott Creek requires a reduction of 82 % from the current load of 2.2 E+11 cfu/day for S-044.

5.5 Uncertainty and Limitations

Because Scott Creek is not gauged and flow was estimated from another gauged stream, the accuracy of each load estimate is unsure. The flow estimates are reliable in the long term, such as over a year, but less so for daily flow estimates.

6.0 IMPLEMENTATION

As discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina* (SCDHEC, 1998), South Carolina has several tools available for implementing this nonpoint source TMDL. SCDHEC will work with the existing agencies in the area to provide nonpoint source education in the Scott Creek Watershed. Local sources of nonpoint source education and assistance include Clemson Extension Service, the Newberry County Soil and Water Conservation Services, and the South Carolina Department of Natural Resources.

SCDHEC is empowered under the State Pollution Control Act to perform investigations of and pursue enforcement for activities and conditions, which threaten the quality of waters of the state. In addition, other interested parties (universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Scott Creek. TMDL implementation projects are given highest priority for 319 funding.

In addition to the resources cited above for the implementation of this TMDL in the Scott Creek Watershed, Clemson Extension has developed a Home-A-Syst handbook that can help urban or rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks. SCDHEC also employs a nonpoint source educator who can assist with distribution of these tools as well as provide additional BMP information.

Using existing authorities and mechanisms, these measures will be implemented in the Scott Creek Watershed in order to bring about an 82 % reduction in fecal coliform bacteria loading to the branch. DHEC will continue to monitor, according to the basin monitoring schedule, the effectiveness of implementation measures and evaluate stream water quality as the implementation strategy progresses.

7.0 REFERENCES AND BIBLIOGRAPHY

Horsley & Witten, Inc. 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Casco Bay Estuary Project, Portland, ME

Novotny, V. and H. Olem. 1994. Water Quality Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

SCDHEC. 1998a. Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina.

SCDHEC. 1998b. Watershed Water Quality Assessment: Saluda River Basin. Technical Report No. 005-98.

Schueler, T. R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Publ. No. 87703. Metropolitan Washington Council of Governments, Washington, DC.

Schueler, T. R. 1999. Microbes and Urban Watersheds: Concentrations, Sources, and Pathways. Watershed Protection Techniques 3(1): 554-565.

United States Environmental Protection Agency (USEPA). 1983. Final Report of the Nationwide Urban Runoff Program, Vol 1. Water Planning Division, US Environmental Protection Agency, Washington, DC.

United States Environmental Protection Agency (USEPA). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, EPA 440/4-91-001.

United States Environmental Protection Agency (USEPA). 2001. Protocol for Developing Pathogen TMDLs. First Edition. Office of Water, EPA 841-R-00-002.

US Environmental Protection Agency (USEPA). 2004 Storage and Retrieval (STORET) Database. http://www.epa.gov/storet/. January 2004.

US Geological Survey. 2004. NWIS Web Data for South Carolina. http://waterdata.usgs.gov/sc/nwis/nwis, January 2004.

APPENDIX A Fecal Coliform Data

Table A-1 Scott Creek (S-044) at SC-34

Date	FC (cfu/ 100ml)
10-May-90	18000
18-Jun-90	600
27-Jul-90	600
24-Aug-90	690
14-Sep-90	20000
04-Oct-90	570
16-May-91	2600
26-Jun-91	820
19-Jul-91	940
23-Aug-91	1000
19-Sep-91	2200
03-Oct-91	3500
07-May-92	4000
04-Jun-92	9000
21-Jul-92	520
06-Aug-92	920
24-Sep-92	9000
22-Oct-92	280
18-May-93	940
22-Jun-93	840
28-Jul-93	1200
17-Aug-93	700
08-Sep-93	9600
20-Oct-93	80
17-May-94	780
29-Jun-94	31000
12-Jul-94	600
09-Aug-94	920
26-Sep-94	620
18-Oct-94	270
05-May-95	620
26-Jun-95	2000
18-Jul-95	620
10-Aug-95	1100
26-Sep-95	520
10-Oct-95	840
23-May-96	520
12-Jun-96	2000
18-Jul-96	560
13-Aug-96	600

Date	FC (cfu/ 100ml)
24-Sep-96	330
16-Oct-96	440
14-May-97	620
18-Jun-97	3000
25-Jun-97	220
08-Jul-97	250
21-Aug-97	390
17-Sep-97	170
15-Oct-97	200
20-May-98	680
02-Jun-98	67000
08-Jun-98	200
07-Jul-98	330
05-Aug-98	1000
01-Sep-98	470
29-Oct-98	140
05-May-99	1000
09-Jun-99	580
19-Jul-99	120
19-Aug-99	66
16-Sep-99	210
04-Oct-99	230
02-May-00	150
27-Jun-00	110
12-Jul-00	86
02-Aug-00	760
06-Sep-00	1600
17-Oct-00	97
10-Jan-01	140
14-Feb-01	100
27-Mar-01	370
16-Apr-01	450
22-May-01	700
05-Jun-01	480
09-Jul-01	290
23-Aug-01	120
17-Sep-01	160
16-Oct-01	490
15-Nov-01	120
11-Dec-01	7800

APPENDIX B Calculations

Table B-1 Calculation of Existing Load

Calculation of Existing Load
Equation: y = 2E+10 X ^ -1.8607

% Exceeded	Load (cfu/day)
0.10	1.45E+12
0.15	6.82E+11
0.20	4.00E+11
0.25	2.64E+11
0.30	1.88E+11
0.35	1.41E+11
0.40	1.10E+11
0.45	8.84E+10
0.50	7.26E+10
0.55	6.08E+10
0.60	5.17E+10
0.65	4.46E+10
0.70	3.88E+10
0.75	3.42E+10
0.80	3.03E+10
0.85	2.71E+10
0.90	2.43E+10
Mean Load	2.18E+11

Table B-2 Calculation of TMDL Load

Calculation of TMDL Load
Target Conc 380 cfu/100ml
From Target Line

% Exceeded	Load (cfu/day)		Flow (cfs)
0.10	1.45E+11		15.62
0.15	8.41E+10		9.04
0.20	6.19E+10		6.66
0.25	5.12E+10		5.51
0.30	4.43E+10		4.77
0.35	3.82E+10		4.11
0.40	3.44E+10		3.70
0.45	3.06E+10		3.29
0.50	2.83E+10		3.04
0.55	2.60E+10		2.79
0.60	2.37E+10		2.55
0.65	2.22E+10		2.38
0.70	1.99E+10		2.14
0.75	1.83E+10		1.97
0.80	1.68E+10		1.81
0.85	1.53E+10		1.64
0.90	1.30E+10		1.40
Mean Load	**3.96E+10**		

Table B-3 Calculation of Percent Reduction

Percent Reduction Required:		
Existing Load:	2.18E+11	cfu/day
TMDL Load:	3.96E+10	cfu/day
Load Reduction:	1.79E+11	cfu/day
Percent reduction:	81.8%	

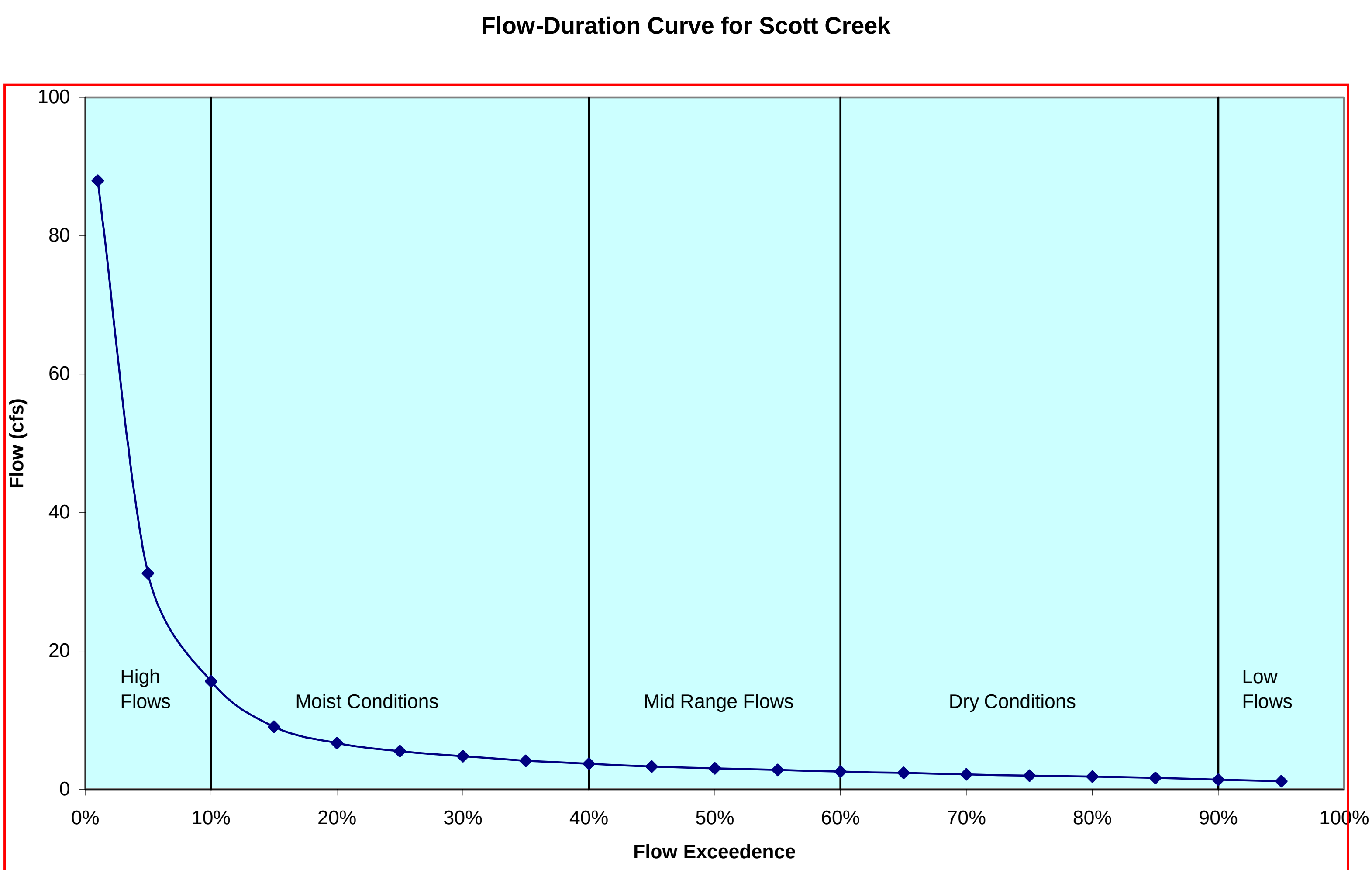

Figure B-1 Flow-Duration Curve for Scott Creek.

APPENDIX C Public Participation